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CONFERENCE REPORT

ON

COTTON INSECT RESEARCH AND CONTROL

Houston, Texas, December 14-16, 1958

(Twelfth Annual Report)

Supplement to 1957 Report

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The twelfth annual conference of State and Federal workers concerned with cotton insect research and control was held at Houston, Texas, from December 14 to 16, 1958. The purpose of these conferences is to review the research and experience of the previous year and to use them as a guide in the preparation of cotton insect control recommendations the following year. This year's report is a supplement to the 1957 report. The sections on pages 13 to 53 which deal with Resistance to Insecticides, Insecticides and Miticides, and Cotton Insects and Spider Mites and Their Control have been revised and are covered in this supplement. In addition, the supplement includes brief statements on Hazards and Precautions in the Use of Insecticides and resistance to insecticides.

CONTENTS

INSECTICIDES AND MITICIDES

Insecticides and miticides useful for the control of cotton pests, and others still under investigation, are listed on page 6. They are grouped according to general type and the stage of their development for practical use. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See statement below on Resistance to Insecticides for details.

Hazards and Precautions in the Use of Insecticides

Development of new synthetic organic insecticides provides more effective means of controlling insects, but numerous problems, such as hazard to man, domestic animals, crops, fish, and beneficial wild life, have been complicated by the use of these new chemicals, although many of them are actually not as toxic to man as are some of the old insecticides. Most insecticides may be harmful to man and animals if used in excessive amounts or if handled carelessly; therefore, they should be used with appropriate precautions and in the amounts and manner recommended.

Those responsible for advocating the proper and safe use of insecticides on cotton are urged to read and become thoroughly familiar with the detailed precautions given on pages 4-9 of the 1957 Conference Report.

Resistance to Insecticides

Resistance to insecticides is the ability in insect strains to withstand exposure to an insecticide which exceeds that of a normal susceptible population, such ability being inherited by subsequent generations of the strain.

Resistance in cotton pests was first demonstrated in the cotton leafworm in 1953. This was followed by development of resistance to one or more recommended insecticides by the salt-marsh caterpillar, cabbage looper, boll weevil, thrips, the cotton aphid, and some species of spider mites. Resistance is suspected in the bollworm, the cotton fleahopper, beet armyworm, lygus bugs, southern garden leafhopper, and cotton leaf perforator. Cotton aphid resistance to BHC and cotton leafworm resistance to toxaphene has become so widespread that they are no longer being recommended for control of these pests.

The importance of resistance in cotton insect control was not fully appreciated until 1955 when the boll weevil was proved to have developed resistance to chlorinated hydrocarbon insecticides in some areas of Louisiana. Since that time resistance has spread and at the end of the 1958 season it was known to occur generally throughout Louisiana, in a large part of Mississippi and Arkansas, and in localized areas in South Carolina, Texas, and North Carolina.

Spider mites first showed resistance to organophosphorus pesticides in cotton fields in 1956. At that time resistance appeared to be restricted to the Pacific mite, Tetranychus pacificus McG., in isolated areas of the San Joaquin Valley in California. This mite was resistant to demeton and parathion. Since 1956, resistance has been found in the two-spotted spider mite, T. telarius (L.), the strawberry spider mite, T. atlanticus McG., and Tetranychus cinnabarinus (Boisduval). This resistance appears to involve most of the commonly used organophosphorus pesticides.

Resistance of cotton pests to recommended insecticides is a serious problem; however, for most pests it is restricted to localized areas. The problem emphasizes the importance of utilizing pesticides having different physiological modes of action and cultural control, especially early stalk destruction, in reducing populations of the boll weevil, the pink bollworm, and other insects where such methods are applicable. Every advantage possible should be taken of biological control agents and when there is a choice, chemicals that are of minimum detriment to beneficial insects should be chosen.

Effect of Environmental Factors on Insect Control

Failures to control insects have often been attributed to ineffective insecticides, poor formulations, poor applications, and improper timing. Recently, resistance has been blamed for many failures in local areas. Extremes of humidity, rainfall, temperature, sunlight, and wind may reduce the effectiveness of any insecticide applied to plants. Climatic factors affect the development of insect populations, certain conditions being favorable to some species and detrimental to others. The rate and total growth of the plants may also be affected by climatic factors.

A combination of an adverse effect on the toxicity of the insecticide plus a favorable effect on growth of the plant and insect population may result in poor control. Conditions favorable to the insecticide and adverse to the insect population will result in effective control. Some insects, for example the boll weevil and lygus bugs, become more difficult to kill as the season progresses. Therefore, one should consider all factors before arriving at a decision as to the specific causes responsible for the failure to obtain control.

Insecticides and Miticides Useful or Showing Promise for the Control of Cotton Pests

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
	Recommended Materials	
Aldrin	Delnav (Hercules AC-528)	Aramite
BHC	Demeton (Systox)	Calcium arsenate
DDT	Di-Syston (Bayer 19639)	Dilan
Dieldrin	Ethion (Nialate)	Sevin
Endrin	Guthion	Sulfur
Heptachlor	Malathion	
Kelthane	Methyl parathion	
Toxaphene	Parathion (ethyl parathion)	
	Thimet (Am. Cyanamid 3911)	
	Trithion	
	Materials showing promise in field tests	
Strobane	Bayer 25141	Barthrin
	Bayer 29493	Tedion
	Diazinon	Thiodan
	Dicapthon	
	Dipterex (Dylox)	
	Monsanto CP-7769	
	Materials showing promise in cage and/or laboratory tests	
Shell SD-4402	American Cyanamid 18706	Tri-calcium arsenite
	Bayer 25198	
	Dimethoate (Am. Cyanamid 12880)	
	General Chemical 3707	
	Shell SD-3562	
	Materials found effective but seldom used on cotton insects [1/]	
Chlordane	Chlorthion	Cryolite
Lindane	EPN	Lead arsenate
Methoxychlor	Phosdrin	Nicotine
Ovex	TEPP	Paris green
		Rotenone

1/ For information on these materials, see earlier reports 1 through 10.

Recommended Materials

Aldrin

Aldrin will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, the fall armyworm, and lygus bugs in either dusts or sprays. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton leafworm, the garden webworm, the cotton aphid, certain species of cutworms and most other lepidopterous larvae, or spider mites. The use of aldrin and mixtures of aldrin and DDT may result in increased populations of aphids and spider mites. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre, and when bollworms are also a problem 0.5 to 1.5 pounds of DDT should be added.

Aldrin (plus a fungicide) dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggot, and false wireworms.

Aldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Aramite

Aramite will control spider mites when applied at 0.3 to 1 pound per acre in either dusts or sprays. Two applications 5 to 7 days apart may be required. Erratic results have been reported from some areas. Aramite may be used in spray mixtures with other insecticides. Care should be used in the preparation of formulations to insure stability. Aramite has essentially no insecticidal activity. The acute toxicity of aramite to warm blooded animals is relatively low, but the potential hazard from a "chronic" standpoint is very high.

BHC

BHC will control the boll weevil, lygus bugs, the rapid plant bug, thrips, stink bugs, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers in either dusts or sprays. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, spider mites, some species of cutworms, and the salt-marsh caterpillar. It has given erratic results against the cotton leafworm, and it has failed to control the cotton aphid in many areas.

Except for use in early-season control, BHC is usually formulated with DDT in the ratio of 3 parts of the gamma isomer to 5 parts of DDT in both dusts and sprays for over-all cotton-insect control. Depending upon the insects to be controlled, this mixture should be applied at rates ranging from 0.3 to 0.6 pound of the gamma isomer and 0.5 to 1.5 pounds of DDT per acre. In some of the western areas a popular formulation has been 2 parts of the gamma isomer to 5 parts of DDT. Where spider mites are a problem, the dust usually contains at least 40 percent of dusting sulfur. Other dusts contain either 2 or 3 percent of the gamma isomer of BHC and 10 percent of DDT and are usually preferred in areas where the bollworm or pink bollworm is the dominant problem. Sprays should be formulated to contain the same amount of each active ingredient as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

It is not advisable to use BHC on cotton that will be in rotation with some crops such as Irish potatoes, and in some areas carrots, peanuts, and tobacco.

BHC is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Calcium Arsenate

Calcium arsenate will control the boll weevil and the cotton leafworm. It has excellent dusting qualities and should be used at the rate of 7 to 15 pounds per acre. Against bollworms it will give fair control at 12 to 15 pounds per acre if applications are properly timed. Generally it is used undiluted against these insects. It often causes an increase in aphid population when used without an aphicide. Alternate applications of calcium arsenate and methyl parathion have given excellent results in some areas.

Calcium arsenate manufactured so as to contain relatively little free lime is compatible with organic insecticides; however, some commercial sources of so-called low-lime calcium arsenate have not been compatible with certain of them. When a mixture containing calcium arsenate, 5 percent of DDT, and 1 percent of parathion is used (see precautions under Parathion), boll weevil, bollworms, cotton aphid, some spider mites, and certain other pests are controlled. Low-lime calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

High suspensible, powdered calcium arsenates have been developed for spraying. In field tests conducted in Arkansas in 1957 and 1958, 8 to 10 pounds of these high suspensible materials in 10 to 18 gallons of water per acre gave results comparable to those obtained with regular calcium arsenate dusts in controlling boll weevils and superior results in controlling bollworms. Several farmers in Arkansas sprayed calcium arsenate successfully in 1958. With good agitation no difficulty is experienced in application. Promising results were also obtained in Louisiana. Care in mixing and applying combined with good agitation are necessary to avoid excessive nozzle stoppage and line and pump wear. A mull or liquid concentrate of calcium arsenate proved difficult to mix and was ineffective against boll weevils in plot tests in Arkansas in 1958, although in tests conducted in Texas satisfactory results were obtained.

Calcium arsenate residue in the soil is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used in fields where rice may be planted. Drifting of the dust may injure other crops, especially rice, soybeans, pecans, and peaches. Care should be taken to avoid drift that might cause bee losses, or onto pastures, especially when applications are made by airplane. Livestock should be kept out of treated fields.

Calcium arsenate is moderately toxic to man and animals and should be used with adequate precautions. It is extremely hazardous to livestock grazing on contaminated feed or forage.

See Hazards and Precautions in the Use of Insecticides.

DDT

DDT in a dust or spray will control the bollworm, the tobacco budworm, the pink bollworm, the fall armyworm, the tarnished plant bug and other lygus bugs, the garden webworm, the western yellow-striped armyworm, the beet armyworm, darkling ground beetles, flea beetles, the white-lined sphinx, the rapid plant bug, the cotton fleahopper, the leaf roller Platynota stultana, and thrips. Unsatisfactory results against thrips have been reported when the temperature exceeded 90° F.

A mixture of DDT at 1 pound and toxaphene at 2 pounds per acre in a spray gave promising results for control of resistant boll weevils in field and laboratory tests.

DDT will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, the cabbage looper, the salt-marsh caterpillar, spider mites, the cotton aphid, stink bugs in the genera Chlorochroa, Euschistus, and Thyanta, or grasshoppers.

DDT is ordinarily used at the rate of 0.5 to 3 pounds per acre, either alone or mixed with other insecticides or miticides.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphicide or a miticide is included in the formulation.

DDT is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Demeton (Systox)

Demeton, the principal active ingredient in Systox, is both a contact and a systemic insecticide with a long residual activity. When applied in a foliage spray at 0.125 to 0.4 pound per acre, it is effective against cotton aphids and spider mites for 2 to 8 weeks, and shows promise for control of the southern garden leafhopper. It does not control the boll weevil, the bollworm, the cotton leafworm, the pink bollworm, or grasshoppers.

Demeton is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dieldrin

Dieldrin in a spray or dust will control the boll weevil, thrips, stink bugs, the cotton fleahopper, lygus bugs, the rapid plant bug, the fall armyworm, grasshoppers, the variegated cutworm, the pale-sided cutworm, the granulate cutworm, the black cutworm, the yellow-striped armyworm, field crickets, and the garden webworm. It is not effective against bollworms at dosages usually recommended for the boll weevil. Spider mites and aphids may increase where dieldrin is used. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre and when bollworms are a problem 0.5 to 1.5 pounds of DDT should be added. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil.

Dieldrin plus a fungicide dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggots, and false wireworms.

Dieldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dilan

Dilan will control the pink bollworm at 1.5 to 3.0 pounds and the salt-marsh caterpillar, lygus bugs, and the cotton leaf perforator at 0.6 to 1.5 pounds per acre. It is not effective against the cotton aphid, the boll weevil, stink bugs, and spider mites.

Dilan is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Di-Syston (Bayer 19639)

Di-Syston as a seed treatment at the rate of 4 pounds of technical per 100 pounds of seed and with the seed planted at the rate of 25 pounds per acre will control thrips, aphids, flea beetles, and spider mites for 2 to 7 weeks after plant emergence. When the seed was treated at 8 pounds per 100 pounds and the planting rate remained 25 pounds per acre, control was extended to 4 to 8 weeks after plant emergence. Aphids were controlled for a longer period than thrips or spider mites. Comparable control was obtained from seed furrow applications of granules at the same rate. Results with side-dress applications were erratic. On irrigated cotton, side-dress applications 30 days after planting at 2 and 4 pounds per acre gave good late-season control of the two-spotted spider mite in California.

Under conditions of cool, damp weather following planting, the seed treatment constitutes a hazard to germination and early plant growth, particularly at the 8-pound dosage.

Of particular interest are 3 years' results in South Carolina on late-season plant protection from cotton aphid attack resulting from seed treatment at either the 4- or 8-pound rate or from soil applications. Aphids failed to develop on plants grown from treated seed or in plots receiving soil applications $4\frac{1}{2}$ to 5 months following treatment when the plants were subjected to repeated applications of calcium arsenate, whereas under the same conditions extremely heavy infestations developed on plants not grown from treated seed or in plots which had not received soil applications in the same field. These results were partially verified at other locations during 1957.

Planting seed should be treated only by custom operators who are able to treat seed adequately and uniformly with suitable precautions against hazards to operators.

Di-Syston is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Endrin

Endrin in a spray or dust will control the boll weevil, the cabbage looper, the celery leaf tier, the bollworm, the tobacco budworm, lygus bugs, the brown cotton leafworm, the cotton leafworm, the salt-marsh caterpillar, the garden webworm, the fall armyworm, grasshoppers, and cutworms when applied at 0.2 to 0.5 pound per acre in most areas. Thrips and the cotton fleahopper are controlled at 0.08 to 0.15 pound. It has not given satisfactory control of cabbage loopers, bollworms, and salt-marsh caterpillars in Arizona. Some failures against the bollworm at 0.2 pound per acre were reported from South Carolina. It will not control spider mites or the pink bollworm. Aphids usually do not build up after use of endrin, but spider mites sometimes do.

Endrin is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Ethion (Nialate)

Ethion at 0.5 to 1 pound per acre applied as a spray or dust will control the desert, Atlantic, and two-spotted spider mites, the cotton aphid and lygus bugs.

Ethion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Guthion

Guthion in a dust or spray at 0.25 to 0.5 pound per acre will control the boll weevil, thrips, the garden webworm, the brown cotton leafworm, the cotton leafworm, and the cotton fleahopper. Erratic results have been obtained against spider mites, lygus bugs, and the cotton aphid. At 0.75 to 1 pound per acre it controls the pink bollworm, the cotton leaf perforator, and usually the bollworm. A mixture of Guthion and DDT has proved more satisfactory than either DDT or Guthion alone against the pink bollworm. This mixture should be applied at weekly intervals at 0.25 to 0.5 pound of Guthion plus 1.5 to 1 pound of DDT per acre, the amount of DDT being decreased as the quantity of Guthion is increased. When applied at 4- to 5-day intervals 0.25 to 0.5 pound of Guthion plus 1 to 0.5 pound of DDT is effective against the pink bollworm, the bollworm, and the boll weevil. It was ineffective against the salt-marsh caterpillar.

Guthion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Heptachlor

Heptachlor in a spray or dust will control the boll weevil, stink bugs, the garden webworm, the fall armyworm, grasshoppers, and lygus bugs at dosages ranging from 0.25 to 1 pound per acre. The field cricket may be controlled with a 5 percent heptachlor dust applied at 20 pounds per acre. When bollworms are a problem, 0.5 to 1.5 pounds of DDT should be added. It is effective against thrips and the cotton fleahopper at dosages from 0.08 to 0.25 pound per acre. It will not control the bollworm, the yellow-striped armyworm, the pink bollworm, the cotton aphid, or spider mites. Spider mite and aphid populations may increase where heptachlor or a heptachlor-DDT mixture is used. Research over a 3-year period showed that two applications annually of heptachlor granules properly timed controlled the boll weevil until late in the season in Alabama.

Heptachlor (plus a fungicide) dusted or slurried onto seed at 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from wireworms, seed-corn maggots, and false wireworms.

Heptachlor is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Delnav (Hercules AC-528)

Delnav will control the cotton leafworm at 0.25 to 0.5 pound per acre. Control of spider mites at 0.4 to 0.6 pound per acre in sprays has been erratic. In California it failed to control leaf rollers at 0.25 to 0.5 pound per acre.

Delnav is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Kelthane

Kelthane is an acaricide with little insecticidal activity. At one pound per acre it controls spider mites and its activity is of long duration. For best results sprays should b e applied at a minimum of 20 gallons per acre. Kelthane sprays applied from airplanes in California gave erratic results. Erratic results have been obtained with dusts.

Kelthane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Malathion

Malathion at 1 to 2 pounds per acre in a spray will control the boll weevil and at 0.25 to 1 pound will control thrips, the cotton aphid, leafhoppers, lygus bugs, the cotton fleahopper, the brown cotton leafworm, the cotton leaf perforator, and the cotton leafworm. Results against whiteflies have been erratic at these dosages. It will not control the salt-marsh caterpillar. Malathion will not control the bollworm and where this insect is a problem 0.5 to 1.5 pounds of DDT should be added. In limited tests in Mississippi, 0.5 pound of malathion at 3-day intervals gave boll weevil control comparable to that obtained at 4- to 5-day intervals with higher dosages. It has given poor results against most spider mite species. Probably due to instability, dust formulations have not been entirely satisfactory in some areas.

Malathion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Methyl Parathion

Methyl parathion at 0.25 to 0.75 pound per acre in a dust or spray will control the cotton aphid, some species of spider mites, the boll weevil, the cotton leaf perforator, and the cotton leafworm, but it has a short residual toxicity. In limited tests 0.25 pound at 3-day intervals gave control of the boll weevil comparable to that obtained at 4- to 5-day intervals with higher dosages. It is not effective against the bollworm and the pink bollworm. It has given poor results against most spider mite species (See table, page 42). When bollworms are a problem 0.5 to 1.5 pounds of DDT should be added. Dust formulations have not been entirely satisfactory in some areas probably due to their instability.

Methyl parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Parathion (ethyl parathion)

Parathion will control the cotton aphid, some species of spider mites, the garden webworm, leafhoppers, the cotton leafworm, the brown cotton leafworm, the cotton leaf perforator, stink bugs, lygus bugs, and the salt-marsh caterpillar at 0.1 to 1 pound per acre. Repeated applications at 1 pound per acre will control the leaf roller, Platynota stultana. It may be applied in a dust or spray, alone or with other insecticides. It gives very little control of the boll weevil,

the fall armyworm, the variegated cutworm, whiteflies, the bollworm, or the pink bollworm. Bollworm infestations sometimes increase after applications of parathion.

Parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Sevin

Sevin as a dust will control the boll weevil, the bollworm, the beet armyworm, stink bugs, lygus bugs, and the cotton leaf perforator at 1 to 2 pounds per acre and thrips, the cotton fleahopper, and the cotton leafworm at 0.5 to 1.0 pound per acre. It is highly effective against the pink bollworm at 2 pounds per acre. It has been difficult to formulate as a satisfactory spray. It does not control spider mites. Aphids do not usually build up following its use.

Sevin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Sulfur

Sulfur has been widely used in dust mixtures for control of certain species of spider mites and the cotton fleahopper. It has a repressive effect upon aphid populations in some areas. Where the desert spider mite is a problem, at least 40 percent of sulfur should be included in all dusts to prevent damaging infestations of this species and to suppress infestations of others. It will not control the two-spotted or the Pacific spider mite. In California excellent control of the strawberry spider mite has been obtained with sulfur at 25 to 30 pounds per acre. Sulfur is most effective when finely ground and when the temperature is 90° F. or above. Precautions should be exercised in applying it to cotton adjacent to cucurbits.

Thimet (Am. Cyanamid 3911)

Thimet as a seed treatment at 2 to 4 pounds of technical per 100 pounds of seed will control thrips for 4 to 5 weeks following plant emergence and aphids and spider mites for 5 to 7 weeks. Seed furrow applications at 1 pound per acre have been effective against thrips, aphids, and spider mites. On irrigated cotton in California side-dressing applications 30 days after planting at 4 pounds per acre were effective in controlling late-season infestations of the two-spotted spider mite.

Under conditions of cool, damp weather following planting, the seed treatment constitutes a hazard to germination and early plant growth.

In Texas in 1957 severe phytotoxicity occurred in two tests in which treated seeds were planted in the same drills in which earlier treated-seed plantings were lost because of heavy rains. Plants recovered but fruiting was delayed.

In South Carolina soil applications of granular Thimet at 10, 20, and 30 pounds of the technical material per acre in May 1956 protected plants from aphid attack throughout the growing season. In 1957 aphid infestations failed to develop following repeated applications of calcium arsenate to cotton planted in these plots. These treatments proved ineffective against the cotton aphid in 1958. Both seed treatment and soil applications of Thimet at planting time at rates of 1 pound per acre resulted in a high degree of plant protection from aphid attack for $4\frac{1}{2}$ to 5 months.

Yields have been erratic, with decreases in some tests and increases in others. In some cases delay in maturity has been indicated.

Planting seed should be treated only by custom operators who are able to treat seed adequately and uniformly with suitable precautions against hazards to operators.

Thimet is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Toxaphene

Toxaphene will control the boll weevil, the fall armyworm, the garden webworm, the tarnished plant bug, the rapid plant bug, cutworms, lygus bugs, grasshoppers, and the cotton leaf perforator when applied at dosages from 1 to 5 pounds per acre in most areas. At 6 pounds per acre it will give fair to good control of stink bugs. Although toxaphene has been used for control of the bollworm at 2 to 4 pounds and the yellow-striped armyworm at 2 to 3 pounds per acre, other materials have given more satisfactory results. It will control the cotton fleahopper and thrips when applied at 0.75 to 1 pound per acre. Dusts and sprays are about equally effective.

Control of the boll weevil, bollworm, the tobacco budworm, the salt-marsh caterpillar, and the cotton leaf perforator is improved where DDT at 0.25 to 1 pound per acre is incorporated in the toxaphene spray. A mixture of toxaphene at 2 pounds and DDT at 1 pound per acre gave promising results for control of resistant boll weevils in field and laboratory tests during 1957 and 1958 but in common with many other insecticides its effectiveness declined toward the end of the season. The use of this mixture also resulted in heavy aphid buildup in many areas. It may also result in increased populations of spider mites.

In Arizona, California, South Carolina, and other areas toxaphene has given poor control of bollworms. In some areas it will not control cabbage loopers, salt-marsh caterpillars, and cotton leaf perforators. Toxaphene will not control the pink bollworm.

Toxaphene is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Trithion

Trithion at 0.5 to 1 pound per acre in a dust or spray will control spider mites and the cotton aphid and appears to have long residual activity. At 1 pound per acre it is effective against the cotton leaf perforator and showed some promise against the boll weevil. It was not effective against the bollworm, salt-marsh caterpillar, cabbage looper, stink bugs, or lygus.

Trithion is extremely toxic to man and animals if taken internally and moderately toxic by skin contact; it should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Materials Showing Promise in Field Tests

Barthrin (6 Chloropiperonyl chrysanthemumate)

Barthrin was promising against pink bollworm and boll weevil at 2 pounds per acre. If proved highly effective, it would have a potential value against resistant strains since its mode of action is probably different than that of either the chlorinated hydrocarbons or phosphorus compounds.

Barthrin is less toxic to man and animals than many of the other insecticides in common use but it should be handled with caution.

See Hazards and Precautions in the Use of Insecticides.

Bayer 25141 (0,0-diethyl 0-p-methylsulfinylphenyl phosphorothioate)

In laboratory tests Bayer 25141 at 0.25 pound per acre was highly effective against the pink bollworm moth and first-instar larvae, the boll weevil, and full-grown cotton leafworm larvae. At 0.5 pound per acre it was effective against second- and third-instar bollworm and salt-marsh caterpillar larvae, but not against the cabbage looper. When used against the pink bollworm moth, the residual life of Bayer 25141 was similar to that of DDT. In field-cage tests at 0.25 to 0.5 pound per acre it was highly effective against the boll weevil.

In field plot tests it was highly effective against the pink bollworm at 0.5 pound per acre. In a field plot test against the boll weevil results were erratic at 0.25 pound per acre but it was effective at 0.5 pound per acre.

Bayer 25141 is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Bayer 29493 (0,0-Dimethyl 4-methylthio-m-tolyl phosphorothioate)

In laboratory tests, Bayer 29493 was highly effective against the boll weevil at the rate of 0.5 to 1 pound per acre. Residues that had aged 3 and 6 days gave mortalities of 85 and 15 percent, respectively. In laboratory and field tests, Bayer 29493 was highly effective against the pink bollworm at the rate of 1 to 1.3 pounds per acre. In field tests at 0.5 pound per acre it was promising for boll weevil control.

Bayer 29493 is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Diazinon

Diazinon appears promising for the control of spider mites, cotton aphids, and leafhoppers (Empoasca spp.) at dosages between 0.125 and 0.5 pound, and is effective against the cotton leaf perforator at 0.5 pound per acre.

Diazinon is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dicapthon

Dicapthon appears promising for the control of the boll weevil, the cotton fleahopper, the desert spider mite, and the cotton aphid at 1 pound per acre. It was also effective against the cotton leafworm at 0.375 pound per acre. Its residual effectiveness seems good when applied at 1 pound per acre. Dicapthon does not control the bollworm.

Dicapthon is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dipterex (Dylox)

Dipterex has been tested in spray and dust formulations. It has given promising control of the cotton aphid and the cotton leafworm at 0.25 to 1 pound per acre; lygus bugs, the brown stink bug, and the leaf roller, Platynota stultana, at 1 pound per acre; the beet armyworm and the western yellow-striped armyworm at 0.5 pound per acre; the beet webworm (Loxostege sticticalis (Linne)) at 0.25 pound per acre; cotton leaf perforator and stink bugs at 0.75 to 1.5 pounds per acre; and the salt-marsh caterpillar at 1.5 pounds per acre. It was effective against pink bollworm moths, but not against larvae at 2 pounds per acre.

Dipterex has given erratic results against bollworms and poor control of the cabbage looper. It was not effective against thrips and the cotton fleahopper at 0.5 to 1 pound per acre.

In some instances dipterex has been phytotoxic.

Dipterex is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Monsanto CP-7769

In laboratory and field tests Monsanto CP-7769 was effective against the boll weevil, the cotton leafworm, tumid and desert spider mites, thrips, and the cotton aphid at rates of 0.25 to 0.75 pound per acre. In laboratory tests it was effective against pink bollworm moths and first-instar larvae at 0.5 to 1 pound per acre, but in a field test it was ineffective against this insect at 0.5 pound per acre. It was ineffective against the bollworm, cabbage looper, and salt-marsh caterpillar when used at the rate of 1 pound per acre.

Monsanto CP-7769 is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Strobane

This material was included in reports for the years 1951 to 1955, inclusive, (in 1951 it was reported as B. F. Goodrich insecticide No. 3960-X14) but because of its unavailability it was dropped after 1955. In previous tests it appeared promising for the control of the boll weevil, bollworm, thrips, lygus bugs, cotton leafworm, and the garden webworm. It will be available for further large-scale tests in 1959.

Strobane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Tedion (2,4,5,4'-Tetrachlorodiphenyl sulfone)

Tedion as a 2 percent dust at 35 to 40 pounds per acre was effective against the two-spotted and Pacific spider mite in California. This material is slow in action and appears to have long residual properties.

Tedion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Thiodan

Thiodan at 0.3 to 1.3 pounds per acre in a dust or spray in laboratory and field tests gave control of the boll weevil, stink bugs, lygus bugs, and bollworms but was no more effective than the chlorinated hydrocarbons against resistant weevils. Aphids built up in some experiments during its use. It did not give satisfactory control of the cotton fleahopper and the pink bollworm. In laboratory tests it showed promise against pink bollworm adults and the salt-marsh caterpillar.

Thiodan is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Materials Showing Promise in Cage and/or Laboratory Tests

Dimethoate (American Cyanamid 12880) (0,0-Dimethyl S-N-methylcarbamoylmethyl) phosphorodithioate)

In laboratory and field cage tests this material was promising against the boll weevil at 0.5 to 1 pound per acre but in field plot tests the results were erratic.

The toxicity of this compound is not fully known but moderate caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

American Cyanamid 18706 (0,0-Dimethyl S-(N-ethylcarbamoylmethyl) phosphorodithioate)

This material was promising against the boll weevil in field cage tests in South Carolina.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Bayer 25198 (0,0-Dimethyl 0-p-methylsulfinylphenyl phosphorothioate)

This material showed promise against the boll weevil in field cage tests in South Carolina.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

General Chemical 3707 (1,3-bis (methoxycarbonyl)-1-propen-2-yl dimethyl phosphate)

In laboratory tests this material was promising against the boll weevil and the bollworm at 1 pound per acre. It was ineffective against the pink bollworm at 0.5 pound per acre.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Shell SD-3562 (Dimethyl 1-(dimethylcarbamoyl)-1-propen-2-yl phosphate)

In laboratory tests this material showed promise against the boll weevil and the pink bollworm adult at 1 pound per acre. It is a systemic insecticide and has shown promise against aphids in laboratory tests.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Shell SD-4402 (1,3,4,5,6,7,8,8-Octachloro-3a,4,7,7a-tetrahydro-4, 7-methanoiso benzofuran)

In laboratory tests this material appeared promising for the control of the boll weevil, the pink bollworm adult, and the bollworm at 0.5 pound per acre.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Tri-calcium arsenite

This material appeared promising against the boll weevil in laboratory tests at 10 pounds per acre.

Tri-calcium arsenite is moderately toxic to man and animals and should be used with adequate precautions. It is extremely hazardous to livestock grazing on contaminated feed or forage.

See Hazards and Precautions in the Use of Insecticides.

CULTURAL PRACTICES

The development of resistance by cotton insects makes good cultural practices imperative. Certain cultural practices reduce and under some conditions may even eliminate the need for insecticides. Several of these practices can be followed by every cotton grower, whereas others are applicable only to certain areas and conditions. Growers following these practices should continue to make careful observations for insects and apply insecticides when needed.

Early Stalk Destruction

The boll weevil resistance problem emphasizes the urgent need for early destruction of cotton stalks. The destruction or killing of cotton plants as early as possible before the first killing frost prevents further population buildup and forces the boll weevil into starvation before it goes into winter quarters. The earlier the weevils are deprived of a food supply the less chance they have of surviving the winter. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem the following season in many areas of the Cotton Belt.

Early stalk destruction and burial of infested debris are generally the most important practices in pink bollworm control. Modern mechanical stalk cutters and shredders facilitate early stalk destruction and complete coverage of crop residues. The shredder-type machine causes a high pink bollworm kill in the shredding operation. Plowing under the crop residue as deeply as possible after the stalks are cut will further reduce the pink bollworm survival. The use of these machines should be encouraged as an aid in the control of both the boll weevil and the pink bollworm. Heavy grazing after harvest is very effective in reducing the overwintering pink bollworm population. See precautions on grazing late treated fields, page 7 of the 1957 Conference Report.

Stub or Volunteer Cotton

Stub, volunteer, and abandoned cotton contributes to insect problems because the stalks and undisturbed soil provide a place for insects to live through the winter. This is especially true with regard to the pink bollworm and the cotton leaf perforator. Volunteer cotton is also the principal overwinter host for the leaf crumple virus of cotton in the southwestern desert areas and for its whitefly vector. All cotton plants should be destroyed soon after harvest.

Planting

Uniform planting of all cotton within a given area during a short period of time will reduce concentration of insects in early fields. A wide spread in planting dates tends to increase populations of pink bollworm, boll weevil, and possibly other insects. Planting during the earliest optimum period for an area also makes earlier stalk destruction possible.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged. Although they do not usually contribute directly to insect control, the higher yields give higher returns from the use of insecticides. Over-fertilization, especially with nitrogen, may unnecessarily extend the period during which insecticidal protection is necessary. Likewise, under-fertilization may nullify gains expected from insecticides.

Other Host Plants of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, legumes, small grains, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Garden webworms, beet armyworms, variegated cutworms, western yellow-striped armyworms, stink bugs, lygus bugs, and other insects may migrate to cotton from alfalfa and other plants. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds. Spider mites spread to cotton from many weeds and other host plants adjacent to cotton fields.

Hibernation Areas

The boll weevil hibernates in well-drained, protected areas in and near cotton fields. Spider mites overwinter on low-growing plants in or near fields. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or

pastures should be destroyed. Such practices are more effective where the cotton acreages are in sizable blocks than in small patches. General burning of ground cover in woods is not recommended.

Seed cotton scattered along roadsides as it is being hauled to the gin may result in the dissemination and survival of the pink bollworm. To minimize this hazard trucks, trailers, and other vehicles in which seed cotton is hauled should be covered.

Gin-plant sanitation should be practiced to eliminate hibernating quarters of the pink bollworm and the boll weevil on such premises. In areas where pink bollworms occur, State quarantine regulations require that gin trash be burned, sterilized, run through a hammer mill or fan of specified size and speed, composted, or given some other approved treatment.

Legumes in Relation to Cotton-Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. The fact that a number of insects and spider mites attack legumes and then transfer to cotton should not discourage the use of legumes, as insect pests may be controlled on both these crops.

CHEMICAL DEFOLIATION AND DESICCATION AS AN AID TO INSECT CONTROL

Chemical defoliation and desiccation of cotton aid in the control of many cotton insects. These practices check the growth of the plants and accelerate the opening of mature bolls, reducing the damage and the late-season buildup of pink bollworms and boll weevils which would otherwise remain to infest next year's crop. They also prevent or reduce damage to open cotton by heavy infestations of aphids, whiteflies, and the cotton leafworm. Stalks should be destroyed and other cultural practices followed, as discussed under "Early Stalk Destruction," after harvest in areas where regrowth is likely to occur before frost or spring plowing.

Defoliation or desiccation permits earlier harvesting and better use of mechanical harvesters. This also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, defoliants and desiccants should not be applied until all bolls that are to be harvested are mature.

Guides for the use of different defoliants and desiccants, developed by the Defoliation Conference, have been issued by the National Cotton Council of America, Memphis, Tenn. They contain information concerning the influence of plant activity, stage of maturity, and effect of

environment on the efficiency of the process, and give details relative to the various needs and benefits. They explain how loss in yield and quality of products may be caused by improper timing of the applications. These guides are based on broad ecological areas rather than on State boundaries. An individual should consult a local agricultural specialist if he has any doubt concerning proper methods, time of application, or actual need for defoliation or desiccation.

PRODUCTION MECHANIZATION IN COTTON-INSECT CONTROL

The increased use of tractors for cotton cultivation has made it possible for more insecticides to be applied with the cultivating operations. Tractors also enable the grower to use shredders, strippers, mechanical harvesters, and larger and better plows, all of which help in the control of the pink bollworm and to some extent the boll weevil.

High-clearance sprayers and dusters have proved to be very useful and satisfactory for application of insecticides and defoliants, especially in rank cotton.

The flaming operation for weed control is of questionable value in insect control.

Mechanical pickers appear to have no direct effect on insect control, but in order for them to perform properly cotton plants are usually defoliated by chemicals, and this does have definite value. However, the use of strippers to harvest the crop is highly desirable from the standpoint of pink bollworm control. They collect infested bolls from the plants which are transported to the gins where a high percentage of the larvae are killed in the ginning process. The use of desiccants in preparing plants for stripping usually prevents further plant growth and, consequently, the late-season buildup of populations.

Stalk shredders not only destroy certain insects, particularly the pink bollworm, but enable the cotton growers over wide areas to have the stalks destroyed before frost, and thereby stop the development of late generations of this insect and the boll weevil.

The increased use of mechanized equipment for cotton production has resulted in large acreages of uniform, even-age stands in some areas. Early-season boll weevil infestations are thus widely dispersed over the fields. Hibernation quarters in or immediately adjacent to the fields are frequently eliminated by these modern cultivation practices.

Certification of mechanical cotton pickers and strippers moving from pink bollworm-infested to noninfested areas is required by quarantine regulations.

MACHINES OF NO VALUE IN INCREASING YIELDS OF COTTON

Bug-catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic Devices

No recognized research agency has yet discovered any evidence that would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Light Traps

Tests in Texas in 1955 with 144 light traps on 3,000 contiguous acres of cotton and other crops showed them to be of no value in the control of the pink bollworm, the bollworm, the cabbage looper, or the corn earworm on corn. However, it has been firmly established that light traps are a valuable tool in pink bollworm and other cotton insect surveys.

Recommended Dosages for the Principal Insecticides and Miticides Used for the Control of Certain Cotton Pests

(Pounds per acre of technical material in a dust or emulsion spray)

Pesticide	Boll weevil	Boll-worm	Cotton aphid	Cotton flea-hopper	Cotton leaf-worm	Cut-worms	Fall army-worm	Grass-hoppers	Lygus and other mirids	Pink boll-worm	Spider mites[1]	Stink bugs	Thrips
Aldrin	0.25-0.75	--	--	0.25	--	--	0.25-0.5	0.10-0.25	0.25-0.75	--	--	--	0.08-0.15
Aramite	--	--	--	--	--	--	--	--	--	--	0.3-1.0	--	--
BHC (gamma)	0.30-0.45	--	--	0.1	--	--	--	0.3-0.5	0.30-0.50	--	--	0.5	0.1-0.2
Calcium arsenate	7-15	-	--	--	7-10	--	--	--	--	--	--	--	--
DDT	--	0.5-2.0	--	0.5	--	1-2[2]	1.0-1.5	--	1.0-1.5	2-3	--	--	0.25-1.5
Demeton[3]	--	--	0.125-0.4	--	--	--	--	--	--	--	0.25-0.4	--	--
Dieldrin	0.15-0.50	--	--	0.15	--	0.3-0.5[2]	--	0.07-0.125	0.15-0.50	--	--	0.5	0.08-0.15
Endrin	0.20-0.50	0.2-0.5	--	0.1	0.2-0.5	0.2-0.5	0.2-0.3	0.2-0.5	0.2-0.5	--	--	--	0.08-0.15
Ethion	--	--	--	--	--	--	--	--	--	--	0.5-1.0	--	--
Guthion	0.25-0.50	--	0.25-0.5	0.25	0.25-0.5	--	--	--	--	0.75-1	0.25-0.5	--	0.25-0.5
Heptachlor	0.25-0.75	--	--	0.25	--	--	0.5-0.75	0.25-0.50	0.25-0.75	--	--	1.0	0.08-0.15
Kelthane	--	--	--	--	--	--	--	--	--	--	1.0	--	--
Malathion	1-2	--	1-2	0.25-1.0	0.25-0.5	--	--	--	0.5-1.0	--	--	--	0.5-1.0
Methyl parathion	0.25-0.75	--	0.25-0.5	--	0.25-0.5	--	--	--	--	--	0.25-0.5	--	0.25-0.50
Parathion	--	--	0.1-0.25	--	0.125-0.25	--	--	--	0.5-1.0	--	0.1-0.4	0.5	--
Sevin[4]	1-2	1-2	--	0.5-1.0	0.5-1.0	--	--	--	1-2	1-2	--	1-2	0.5-1.0
Sulfur[4]	--	--	--	--	--	--	--	--	--	--	20-30	--	--
Toxaphene	2-4	2-4	--	1.0	--	2-5	2-3	1.0-2.5	2-3	--	--	6.0	0.75-1.0
Trithion	--	--	--	--	--	--	--	--	--	--	0.5-1.0	--	--

1/ Not all species of spider mites are controlled with these materials. See table page 42.

2/ Does not control all species.

3/ Spray only.

4/ Dust only.

COTTON INSECTS AND SPIDER MITES AND THEIR CONTROL

The insects and spider mites injurious to cotton and the recommended chemicals and procedures for their control are discussed in this section. For recommended dosages of the principal insecticides and miticides used for the control of the most important cotton pests see table on page 27. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See Resistance to Insecticides, page 4, for details.

Beet Armyworm (Laphygma exigua (Hbn.))

The beet armyworm is primarily a pest of seedling cotton, but it may also attack older plants. Squares and blooms may be destroyed, and feeding on the bracts may cause bolls to shed. DDT at 1 to 1.5 and Sevin at 1 to 2 pounds per acre are effective. A spray containing methyl parathion at 0.5 pound and endrin at 0.5 pound was also effective and widely used in Arizona in 1958.

Boll Weevil (Anthonomus grandis Boh.)

The boll weevil is the most important pest of cotton in the eastern half of the Cotton Belt. The effectiveness of insecticides approved for its control will vary not only in different localities but also with the season. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be controlled. Dosages of technical material that have controlled the boll weevil in one or more areas are as follows:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.25-0.75
BHC (gamma isomer)	0.30-0.45
Calcium arsenate	7-15
Dieldrin	0.15-0.5
Endrin	0.2-0.5
Guthion	0.25-0.5
Heptachlor	0.25-0.75
Malathion	1-2
Methyl parathion	0.25-0.75
Toxaphene	2-4
Toxaphene-DDT (2:1)	2-3 plus 1.0-1.5
Dust only:	
Sevin	1-2

When these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, the tobacco budworm, and spider mites may develop when some of these insecticides are used alone. To avoid a rapid buildup of the bollworm and the tobacco budworm, DDT should always be added to aldrin, BHC, dieldrin, Guthion, malathion, methyl parathion, and heptachlor. (For rates see section under the respective insecticides or pests). Toxaphene, if properly timed, will control bollworms without DDT in some areas. However, if it is used alone late in the season, careful checks should be made at 3- to 5-day intervals, and if their numbers are found to be increasing, DDT should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or DDT formulated with aldrin, dieldrin, endrin, heptachlor, or toxaphene. Spider mites may build up rapidly after the use of the last five chemicals and BHC, either alone or with DDT. Careful checks should be made at 5- to 7-day intervals, and if these pests are found to be increasing control measures should be started at once. (See sections on cotton aphids and spider mites).

Insecticides should be applied for boll weevil control when definite need is indicated. Mid- and late-season applications should be made every 3 to 5 days as long as control is necessary. Fields should be inspected at least weekly until the crop is mature. Where early-season control is practiced, these applications are usually spaced a week apart during the period of abundance of overwintered weevils.

Bollworm (Heliothis zea (Boddie))
and Tobacco Budworm (H. virescens (F.))

The bollworm and the tobacco budworm are the common "bollworms" attacking cotton. Several other species of lepidopterous larvae that cause boll injury are discussed elsewhere in this report.

Effective control of bollworms depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the fruiting period are essential. For the most effective control it is essential that insecticide applications be made when larvae are small.

Bollworms are most effectively controlled with DDT, endrin, or a toxaphene plus DDT mixture, and in some areas are usually satisfactorily controlled with toxaphene. Sevin dust has also given satisfactory control of bollworms.

Dosages of technical material that have controlled bollworms in one or more areas are as follows:

	Pounds per acre
Sprays or dusts:	
DDT	0.5-2.0
Endrin	0.2-0.5
Toxaphene	2-4
Dust only:	
Sevin	1-2
Spray only:	
Toxaphene-DDT (2:1) . .	2-3 plus 1.0-1.5

In areas where spider mites are a problem, dusts containing organic insecticides should include a least 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cabbage Looper (Trichoplusia ni (Hbn.))

The cabbage looper and related species are becoming more important as pests of cotton in many areas. The following materials applied at 5-day intervals beginning when larvae are small have given good control in one or more areas:

	Pounds per acre
Sprays or dusts:	
Endrin	0.4-0.5
Endrin-methyl parathion mixture . .	0.5 plus 0.5

Cabbage looper is frequently controlled by a virus disease. When diseased loopers are commonly found, chemical control may be delayed or deleted.

Cotton Aphid (Aphis gossypii Glov.)

Heavy infestations of the cotton aphid may occur on cotton after the use of certain insecticides, and on seedling cotton where no insecticides have been applied. Aphid buildup in the boll weevil areas can usually be prevented by any of the following treatments:

1. Parathion 1 percent in low-lime calcium arsenate dust or added at the rate of 0.1 pound per acre to dusts or sprays of the following insecticides when formulated with DDT and used at the recommended rate for boll weevil control: Aldrin, dieldrin, heptachlor, and toxaphene.
2. Toxaphene at 2 to 3 pounds per acre in every application (where not formulated with DDT), in a dust or spray.
3. Sevin at 1 to 2 pounds per acre in every application, applied as a dust.
4. Endrin at 0.2 to 0.5 pound per acre in every application (where not formulated with DDT), in a dust or spray.
5. Methyl parathion or Guthion at 0.25 to 0.5 pound or malathion at 1 to 2 pounds per acre in a dust or spray in every application or alternately with calcium arsenate.

When aphid infestations are heavy and rapid kill is needed, any one of the following treatments is usually effective:

1. Parathion at 0.1 to 0.25 pound per acre, in a dust or spray.
2. Demeton at 0.125 to 0.4 pound per acre, in a spray.
3. Malathion at 1 to 2 pounds per acre, in a dust or spray.
4. Methyl parathion at 0.25 to 0.5 pound per acre, in a spray or dust.

Planting seed treated with Thimet or Di-Syston at a rate to give 0.5 to 1 pound per acre has resulted in aphid control on seedling cotton, and suppressed aphid infestations later in the season in some locations.

Cotton Fleahopper (Psallus seriatus (Reut.)) and
Black Fleahopper (Spanogonicus albofasciatus (Reut.))

These insects can be controlled with the following insecticides at the rates of technical material shown:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.25
BHC	0.1
DDT	0.5
Dieldrin	0.15
Endrin	0.1
Guthion	0.25
Heptachlor	0.25
Malathion	0.25-1.0
Toxaphene	1
Dust only:	
Sevin	0.5-1.0

Cotton Leaf Perforator (Bucculatrix thurberiella Busck)

The cotton leaf perforator is at times a serious defoliator of cotton in certain areas of southern California and Arizona. It is controlled with any of the following insecticides at the dosages of technical material shown:

	Pounds per acre
Sprays or dusts:	
Dilan	0.6-1.0
Malathion	1
Methyl parathion	0.5
Parathion	0.5
Toxaphene	5
Dust only:	
Sevin	1.75

Repeat applications may be necessary. Sprays are more effective than dusts.

If bollworms are present, DDT should be added to any of these insecticides except Sevin at the rate of 0.5 to 1.5 pounds per acre.

Cotton Leafworm (Alabama argillacea (Hbn.))

The following insecticides will control the cotton leafworm at the dosages of technical material shown:

	Pounds per acre
Sprays or dusts:	
Calcium arsenate	7-10
Endrin	0.2-0.5
Guthion	0.25-0.5
Malathion	0.25-0.5
Methyl parathion	0.25-0.5
Parathion	0.125-0.25
Dust only:	
Sevin	0.5-1.0
Spray only:	
Delnav (Hercules AC-528)	0.25-0.5

Cutworms

Several species of cutworms, including the following, may develop in weeds or crops, especially legumes, and then attack adjacent cotton or cotton planted on land previously in weeds or legumes:

Black cutworm (Agrotis ypsilon (Rott.))
Pale-sided cutworm (Agrotis malefida Guen.)
Variegated cutworm (Peridroma margaritosa (Haw.))
Granulate cutworm (Feltia subterranea (F.))
Army cutworm (Chorizagrotis auxiliaris (Grote))

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas irrigation forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. If an infested area is plowed under 3 to 6 weeks before the cotton crop is seeded, it may not be necessary to use an insecticide.

The following insecticides will control cutworms at the dosages of technical material shown:

	Pounds per acre
Sprays or dusts:	
DDT	1.0-2.5
Dieldrin	0.3-0.5
Endrin	0.2-0.5
Toxaphene	2-5
Spray only:	
Toxaphene-DDT (2:1)	2-3 plus 1.0-1.5

Poison baits containing toxaphene, DDT, dieldrin, or endrin have been satisfactory. Baits are frequently more effective than sprays or dusts against some species of cutworms.

Fall Armyworm (Laphygma frugiperda (J. E. Smith))

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following insecticides will control them at the dosages of technical material shown:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.25-0.5
BHC-DDT	0.3 + 0.5 - 0.45 + 0.75
DDT	1-1.5
Endrin	0.2-0.3
Heptachlor	0.5-0.75
Toxaphene	2-3

The results obtained from these materials have varied in different states; therefore, local recommendations should be followed. (Also see Bollworm, page 29).

False Wireworms (Blapstinus and Ulus spp.)

Darkling ground beetles, the adults of false wireworms, occasionally affect the stand of young cotton in the western areas. The larvae may be controlled by slurrying 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane with a suitable fungicide onto each 100 pounds of planting seed. Adults on young plants may be controlled with toxaphene, DDT, or toxaphene-DDT mixture (2:1) applied in sprays at 1 to 2 pounds per acre. Sprays containing dieldrin at 0.25 pound or aldrin at 0.5 pound per acre have given excellent control. Thimet as a seed treatment at 1 pound per acre will also control these insects on seedlings.

Field Cricket (Acheta assimilis F.)

The field cricket occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California and in Arizona. During periods of drought late in the season they may feed on the seed of open bolls, especially in the Delta sections of Arkansas, Louisiana, and Mississippi. This feeding is usually done at night by crickets that hide during the day in deep cracks in the soil. Crickets may be controlled by foliage applications of a 10-percent DDT or 2.5-percent dieldrin, aldrin, or heptachlor dust at 20 to 30 pounds per acre. A BHC dust containing 2 percent gamma plus 5 percent of DDT plus 40 percent of sulfur applied at 15 to 20 pounds per acre is also effective.

Garden Webworm (Loxostege similalis (Guen.))

The garden webworm may be controlled on cotton with the following insecticides applied as dusts or sprays at the per-acre dosage indicated: BHC-DDT to give 0.45 pound of gamma and 0.75 pound of DDT, toxaphene at 3 pounds, parathion at 0.15 pound, DDT at 1 pound, toxaphene-DDT (3:1) at 3 pounds, heptachlor at 0.4 pound, dieldrin at 0.3 pound, and endrin at 0.3 pound. DDT has given better control in sprays than in dusts, but is generally less effective than the other materials. Control measures should be applied as soon as possible after the worms appear.

Grasshoppers

Several species of grasshoppers, including the following, sometimes attack cotton:

Differential grasshopper (Melanoplus differentialis (Thos.))
Migratory grasshopper (M. bilituratus Walker)
Red-legged grasshopper (M. femur-rubrum (DeG.))
Two-striped grasshopper (M. bivittatus (Say))
American grasshopper (Schistocerca americana (Drury))
Lubber grasshopper (Brachystola magna (Gir.))
Desert grasshopper (Trimeritropis pallidipennis (Burm.))

Most of the material previously identified in the United States as M. mexicanus (Sauss.) is now recognized as M. bilituratus Walker. This species will now be known as the migratory grasshopper. So far as is now known, M. mexicanus occurs only in Mexico and the Big Bend area of Texas.

The American grasshopper overwinters as an adult, and in the spring deposits eggs in the fields, but most other species overwinter as eggs in untilled soil, fence rows, sod waterways, around stumps, and similar locations. The species overwintering in the egg stage can best be controlled with early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, heptachlor, dieldrin, endrin, toxaphene, or BHC have largely replaced poison baits, particularly where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 to 2 days. Aldrin, dieldrin, endrin, and toxaphene are very effective but slower in their action; however, they remain effective up to several weeks.

Dosages of technical material suggested to control grasshoppers come within the following ranges:

	Pounds per acre
Aldrin	0.1-0.25
BHC, gamma	0.3-0.5
Dieldrin	0.07-0.125
Endrin	0.2-0.5
Heptachlor	0.25-0.5
Toxaphene	1-2.5

The lowest dosages are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the material is applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control, particularly in sparse vegetation.

The desert grasshopper caused considerable damage to young cotton in Arizona in 1958. Both nymphs and adults were killed when they fed on cotton seedlings grown from Thimet treated seed.

Lygus Bugs and Other Mirids

Several species of lygus bugs and other mirids, including the following, are often serious pests of cotton:

Tarnished plant bug (*Lygus lineolaris* (P. de B.))
Other lygus bugs (*L. hesperus* Knight and *elisus* Van D.)
Rapid plant bug (*Adelphocoris rapidus* (Say))
Superb plant bug (*A. superbus* (Uhl.))
Ragweed plant bug (*Chlamydatus associatus* (Uhl.))
Other mirids (*Creontiades debilis* (Van D.), *C. femoralis* (Van D.), *Neurocolpus nubilus* (Say), and *Rhinacloa forticornis* Reut.)

These insects cause damage to squares, blooms, and small bolls of cotton and constitute a major problem, particularly in the vicinity of alfalfa fields in the irrigated areas of the West.

The following insecticides will control lygus bugs and other mirids at the dosages of technical material shown:

	Pounds per acre
Dust or spray:	
Aldrin	0.25-0.75
BHC	0.3-0.5
DDT	1.0-1.5
Dieldrin	0.15-0.5
Endrin	0.2-0.5
Heptachlor	0.25-0.75
Malathion	0.5-1.0
Parathion	0.5-1.0
Toxaphene	2-3
Dust only:	
Sevin	1-2

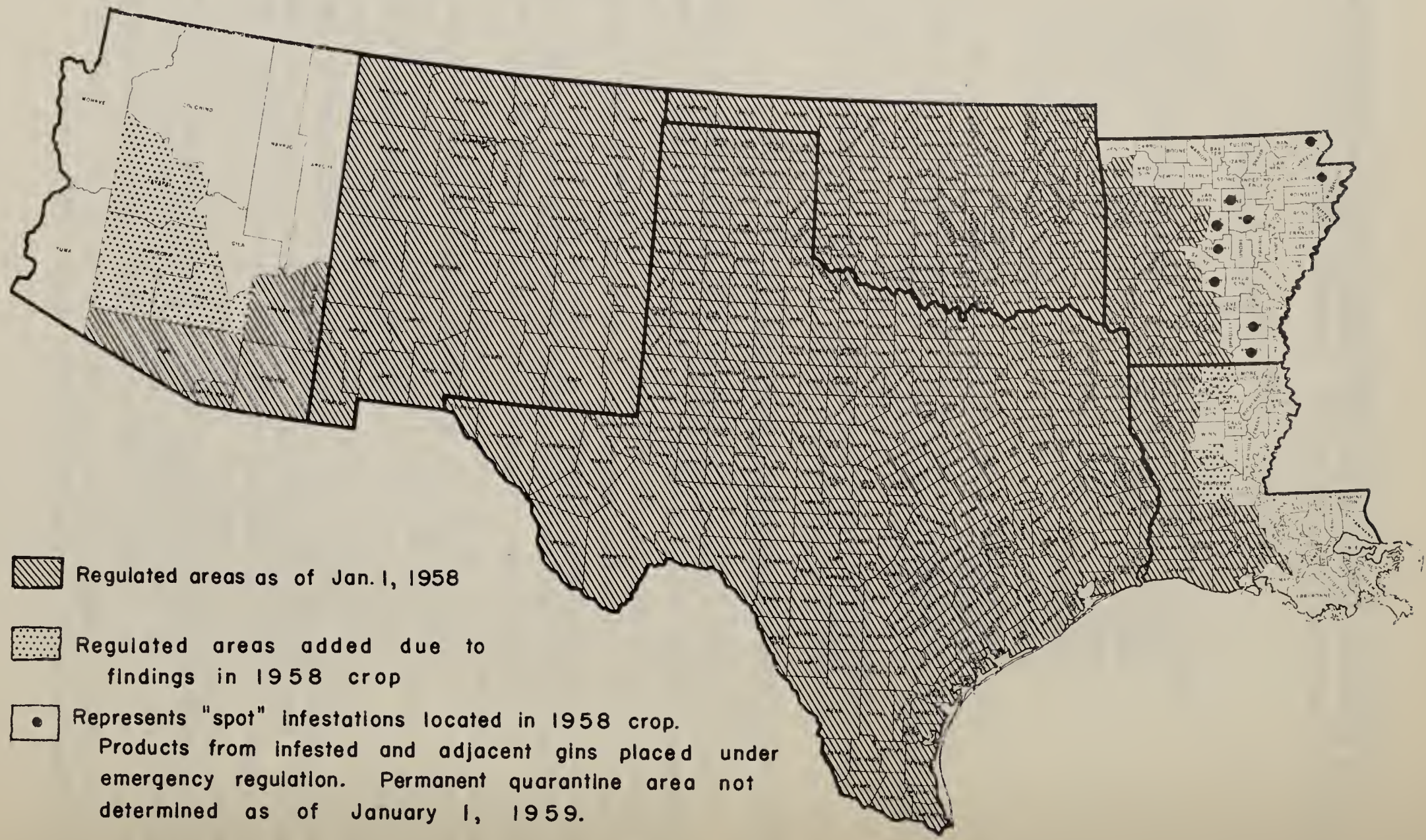
Pink Bollworm (Pectinophora gossypiella (Saund.))

The pink bollworm was detected in nine additional counties in Arkansas during 1958--Ashley (2), Clay (1), Cleburne (1), Drew (1), Faulkner (3), Grant (1), Mississippi (1), Pulaski (1), and White (2). It was also found in five parishes in Louisiana that were not known to be infested in January--Grant (2), Lincoln (5), Ouachita (2), Rapides (1), and Union (2). Figures in parentheses indicate the number of worms found. In addition, heavy infestations developed on a number of farms in the western part of Maricopa County, Arizona, and eradication measures were promptly inaugurated. Infestations were found scattered over much of the county later in the season, and these spread into adjoining Pinal County. The spread in these three States led to the most intensive inspection ever conducted for pink bollworm on the periphery of the infested area, both inside and outside. A very serious situation is developing in Texas due to the steady increase each year in pink bollworm populations in central Texas. Inspections in Sonora and Baja California were negative, and the Department of Agriculture of Mexico continues to maintain adequate regulations to prevent the pink bollworm from becoming established in its important cotton-producing States in the northwestern part of the Republic.

See map on page 38 for regulated area in the United States as modified because of new infestations in the 1958 crop.

PINK BOLLWORM REGULATED AREAS

JANUARY 1, 1959



Regulated areas as of Jan. 1, 1958

Regulated areas added due to findings in 1958 crop

Represents "spot" infestations located in 1958 crop. Products from infested and adjacent gins placed under emergency regulation. Permanent quarantine area not determined as of January 1, 1959.

U.S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

Quarantine requirements.--Quarantine requirements were further simplified in 1957 without lowering any of the safeguards against the spread of the pest. Major changes in the latest revision of Quarantine No. 52 include:

1. Revision of language and format to conform to other recently revised quarantines and to describe the regulated areas in Administrative Instructions.
2. Division of the regulated area into (a) generally infested area and (b) eradication area.
3. Inclusion of all of New Mexico in the regulated area, although cotton is grown only in the southern counties. This eliminates considerable issuance of permits without increasing pest risk. This same procedure has been followed heretofore in Oklahoma and Texas.
4. Broadening the definition for "cotton waste" to include all forms of lint waste produced at gins, oil mills, or textile mills. This revision will simplify the handling of lint waste without increasing pest risk.
5. A more precise definition of the "Northern States" to which certain regulated articles may be shipped without treatment.
6. Waiver of certification on movement of cottonseed meal and cake and on compressed cotton moving by common carrier to any destination.

The regulations, in general, require that all infested cotton or articles be treated to free them of living pink bollworms before they are moved to free areas.

Cultural control.--The pink bollworm, unlike any other cotton insect, hibernates only in the fields in which it is produced unless taken away in the harvesting of the crop. Approved cultural practices greatly reduce the overwintering population and are the most effective means of combating this pest. Mandatory cultural-control zones are in effect in all the regulated areas of Arkansas and Louisiana, in all of south Texas, and in the southern portions of central and east Texas. There are also mandatory cultural-control zones in Mexico adjacent to Texas.

The same cultural practices followed in the control of the pink bollworm greatly reduce the boll weevil carryover, particularly when the plants are destroyed while still green.

Recommended control practices include the following:

1. Shorten the planting period and plant at the optimum time for your locality. Use seeds of an early-maturing variety, which have been culled, treated with a fungicide, and tested for germination.
2. Leave as thick a stand as has been recommended for your section and type of soil.
3. See that the cotton crop is produced in the shortest practicable time. Early-season control of certain insects has proved advantageous in some States but not in others. Practice early-season control if recommended by your State and locality by controlling thrips, aphids, the cotton fleahopper, the boll weevil, cutworms, and any other insects which may retard the growth and fruiting of young plants. Protection of early fruit will assure an early harvest.
4. Withhold late irrigation and use defoliants or desiccants to hasten the opening of the bolls.
5. Destroy cotton stalks immediately after harvest, preferably by shredding. The shredder has killed 70 to 75 percent of pink bollworm larvae in green bolls in south Texas. Okra stalks should be destroyed at the same time because this plant is a preferred alternate host of the pink bollworm.

After the cotton stalks have been destroyed, the residue should be plowed under as deeply as possible. Pink bollworm survival is highest in bolls on the soil surface and is six times as high in bolls buried only 2 inches as in bolls buried 6 inches deep. All sprout and seedling cotton and okra developing after plowing should be destroyed before fruiting to create a host-free period between crops.

In cold arid areas where temperatures of 15° F. or lower prevail, stalks should be left standing during the winter, since the highest mortality in such areas occurs in bolls on the standing stalks. If the crop debris is plowed under in the late fall or early winter, the fields should be winter irrigated to hasten decomposition of the bolls.

These recommended measures are most effective when carried out on a community- or county-wide basis, and these practices will pay large dividends in savings on insecticides.

Control with insecticides.--Where infestations are heavy, crop losses from the pink bollworm can be reduced by proper use of insecticides. Weekly applications of 2 pounds of Sevin, 2 to 3 pounds of DDT, 0.75 to 1 pound of Guthion, or 0.25 to 0.5 pound of Guthion plus 1.5 to 1 pound of DDT will control the pink bollworm. Guthion

at 0.25 to 0.5 pound plus DDT at 1 to 0.5 pound or Sevin at 1 to 2 pounds per acre when applied at 4- to 5-day intervals will control the pink bollworm, boll weevil, and bollworm. DDT can also be mixed with the other organic insecticides used for the control of cotton pests, and when the interval of application is 4 to 5 days the mixture should contain enough DDT to give 1 to 1.5 pounds per acre. The mixtures of Guthion plus DDT have proved to be the more effective for pink bollworm control than either DDT or Guthion alone.

Eradication measures.--Early programs of eradication were dependent primarily on non-production of cotton in the affected area plus a security zone around the known infestation. The last infestation eradicated in Arizona in 1947 used a combination of such practices as (1) stalk destruction and field clean-up, (2) deep plowing under of crop residues, (3) elimination of volunteer plants, (4) prohibition of production of stub cotton, and (5) an insecticide program involving eight applications early in the season of a DDT-sulfur dust. Gin sanitation and heat treatment of cottonseed were an important phase of the over-all program.

The essentials of an eradication program have not changed materially in the interim since that program was inaugurated in 1947. However, improved stalk shredders which kill from 65 to 85 percent of the pink bollworms in bolls passing through them are more effective than roller-cutters then available and can be utilized to replace expensive hand cleaning formerly required. Also, better defoliants are available which can be applied to hasten maturity of the late bolls, which will in turn hasten harvest, stalk shredding, and plow-under of crop residues. The importance of a short, uniform planting period at the optimum time is recognized as a distinct aid in the further reduction of initial infestations from overwintering larvae. Eradication of the pink bollworm is possible in any given area not subject to constant reinfestation from nearby areas.

Seed-Corn Maggot (Hylemya cilicrura (Rond.))

The seed-corn maggot may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane in a wettable powder mixed with a suitable fungicide and applied onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton:

Strawberry (Atlantic) spider mite (Tetranychus atlanticus McG.)
Four-spotted spider mite (T. canadensis McG.)
Desert spider mite (T. desertorum Banks)
Pacific spider mite (T. pacificus McG.)
Schoene spider mite (T. schoenei McG.)
Tumid spider mite (T. tumidus Banks)
Two-spotted spider mite (T. telarius (L.))
Also T. cinnabarinus (Boisduval), T. lobosus Boudreaux,
T. gloveri Banks, and T. ludeni Zacher
Brown wheat mite (Petrobia latens (Muell.))

These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential. The use of organic insecticides for cotton-insect control has been a factor in increasing the importance of spider mites as pests of cotton.

The following table lists the species of spider mites and the miticides which have been found to be effective in their control:

	Species of Mite						
Miticide	Strawberry (Atlantic)	Desert	Pacific	Tumid	Two-spotted	Tetranychus cinnabarinus (Boisduval)	Brown wheat
Aramite	1.0	0.3-0.75	1.0	0.3-0.75	0.75-1.0	0.75-1.0	
Demeton	0.25-0.40	0.25-0.40	0.25-0.40	0.25-0.40	0.25-0.40	0.25-0.40	
Parathion		0.1-0.25		0.1-0.25	0.2-0.4	0.2-0.4	0.3
Methyl parathion		0.25-0.5		0.25-0.5			
Sulfur	20-25	20-25		20-25			25-30
Kelthane	1.0	1.0	1.0	1.0	1.0		
Trithion	0.5-1.0	0.5-1.0		0.5-1.0	0.5-1.0	0.5-1.0	
Ethion	0.5-1.0	0.5-1.0		0.5-1.0	0.5-1.0		
Guthion		0.25-0.5		0.25-0.5			

Thimet or Di-Syston as a seed treatment at 0.5 to 1 pound per acre and as a seed furrow application at 2 and 4 pounds per acre will give control on seedling cotton. In irrigated areas a sidedress at 2 and 4 pounds per acre has given late-season control in California.

In some areas mites may be controlled by including a suitable miticide at a comparatively low rate in all insecticide applications. For control of some species and suppression of others at least 40 percent of sulfur may be incorporated in dusts. Elemental sulfur cannot be incorporated in sprays applied at low gallonage, but other miticides may be substituted. Sulfur dust is most effective when finely ground and when applied at temperatures above 90° F. Thorough coverage is essential.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Conchuela (Chlorochroa ligata (Say))
Say stink bug (C. sayi Stal)
Southern green stink bug (Nezara viridula (L.))
Green stink bug (Acrosternum hilare (Say))
Brown cotton bug (Euschistus impictiventris Stal)
Brown stink bug (E. servus (Say))
(also E. variolarius (P. de B.), E. tristigmus (Say), and E. conspersus Uhl.)
Red-shouldered plant bug (Thyanta custator (Fab.))
(also T. rugulosa (Say), T. brevis Van D., and T. punctiventris Van D.)

The importance of these pests and the species involved vary from year to year and from area to area. The damage is confined principally to the bolls and results in reduced yields and lower quality of both lint and seed.

The following insecticides applied at the rates of technical material shown have given control of stink bugs:

	Pounds per acre
Sprays or dusts:	
BHC	0.5
Dieldrin	0.5
Heptachlor	1.0
Parathion	0.5
Toxaphene	6
Dust only:	
Sevin	1-2

Thrips

Thrips often injure cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The following species have been reported as causing this injury:

Tobacco thrips (Frankliniella fusca (Hinds))
Flower thrips (F. tritici (Fitch))
(also F. runneri (Morg.), F. exigua Hood,
F. occidentalis (Perg.), and F. gossypiana Hood)
Onion thrips (Thrips tabaci Lind.)
Sericothrips variabilis (Beach)

In some areas cotton plants usually recover from thrips injury to seedlings; therefore, control is not recommended unless the stand is threatened. In other areas thrips damage is more severe and control measures are generally recommended. Injury by thrips alone, or the combined injury of thrips and disease, may reduce or even destroy stands of young plants. A heavy infestation may retard plant growth and delay fruiting and crop maturity. Although thrips are predominantly pests of seedlings, damaging infestations sometimes occur on older cotton in certain areas.

The following insecticides at the per-acre dosages of technical material indicated are recommended when the situation warrants their use:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.08-0.15
BHC	0.1-0.2
DDT	0.25-1.50
Dieldrin	0.08-0.15
Endrin	0.08-0.15
Guthion	0.25-0.50
Heptachlor	0.08-0.15
Malathion	0.5-1.0
Methyl parathion	0.25-0.50
Toxaphene	0.75-1.0
Dust only:	
Sevin	0.5-1.0

When applications are made by airplane, the above dosages should be increased by at least 50 percent.

Parathion and methyl parathion are effective against thrips but are not generally recommended because their residual toxicity is shorter than that of insecticides commonly used for thrips control. Thimet and Di-Syston as seed treatments at 0.5 to 1 pound per acre will also give control on seedling cotton.

The bean thrips (Hercothrips fasciatus (Perg.)) is an occasional mid-season pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied in either a spray or dust.

Scirtothrips sp. causes severe crinkling of top leaves of cotton in localized areas of Arizona, California, Mississippi, and Texas.

Kurtomalthrips marrilli Moulton was described in 1927 from specimens taken on cotton at Gila Bend, Arizona. It was collected from cotton at Seeley, California, on May 2, 1930, at Laveen, Arizona, on July 23, 1943, and was reported as causing severe injury to cotton at Gila Bend, Arizona, in July 1957.

White-fringed Beetles (Graphognathus spp.)

White-fringed beetles are pests of cotton and many other farm crops in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The larvae feed on the roots of young plants. These insects can be controlled by good cultural practices and with insecticides. Recommended cultural practices include the following:

1. In heavily infested areas plant oats or other small grains.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvetbeans, or other favorable host plants of the adult beetles, to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvetbeans. Prevent the growth of broadleaved weeds such as cocklebur and sicklepod.
4. Improve poor soils by turning under winter cover crops.

The following insecticides when applied at the given dosages are effective against white-fringed beetle larvae. Either broadcast the insecticide on the soil when preparing it for planting, and immediately

work it thoroughly into the upper 3 inches, or apply it alone or mixed with fertilizer, below the depth of seed in the drill row at time of planting. The insecticide may be used in a spray, dust, or granules.

	Pounds per acre	
	Broadcast	In drill row
Aldrin	2	0.75
DDT	10	2
Dieldrin	1.5	0.5
Heptachlor	2	0.75

Broadcast applications remain effective as follows: Aldrin or heptachlor for 3 years, DDT for 4 years, and dieldrin for 4 or more years. Drill-row applications must be renewed each year.

When applied to the foliage as recommended for the control of other cotton insects, toxaphene, a BHC-DDT mixture, or any one of the insecticides named above will give a residue in the soil which aids in the control of white-fringed beetles.

Wireworms

Several species of wireworms are associated with cotton. Damage is caused by the sand wireworm (Horistonotus uhlerii Horn) in South Carolina, Louisiana, and Arkansas and by the Pacific Coast wireworm (Limonius canus Lec.) in California. Adults of the tobacco wireworm or spotted click beetle (Conoderus vespertinus (F.)) are frequently found on the cotton plant, but the amount of damage the larvae cause to cotton is insignificant. Wireworms together with false wireworms and the seed-corn maggot sometimes prevent the establishment of a stand. To control these insects treat the seed with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane plus a suitable fungicide per 100 pounds in a slurry.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton by the sand wireworm. Aldrin, dieldrin, endrin, heptachlor, lindane, and BHC as soil treatments are also effective against wireworms.

Yellow-striped Armyworm (Prodenia ornithogalli Guen.)
and Western Yellow-striped Armyworm (P. praefica Grote)

These insects sometimes cause considerable damage to cotton. The yellow-striped armyworm is difficult to kill with insecticides.

However, toxaphene at 2.5 pounds, DDT at 1 pound, or dieldrin at 0.3 pound per acre in an emulsion spray gives fair control when used in the early stages of worm development. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at 15 pounds per acre also give good kills of both large and small larvae.

The western yellow-striped armyworm, which attacks cotton in California, is easily controlled with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre applied in a dust or spray. Migrations from surrounding crops may be stopped with barriers of 10-percent DDT or 20-percent toxaphene at 2 to 4 pounds per 100 linear feet.

Miscellaneous Insects

Several Anomis leafworms are known to occur in the cotton-growing regions of Africa, Asia, North, Central, and South America, and the East and West Indies. Three species--erosa Hbn., flava fimbriago Steph., and texana Riley--occasionally damage cotton in the United States. They are often mistaken for the cotton leafworm, and are sometimes found on the same plants with it. Although specific control data are lacking, the insecticides recommended for control of the cotton leafworm might also be effective against Anomis leafworms.

The brown cotton leafworm (Acontia dacia Druce) was collected from three counties in Texas in 1953. Since then damaging infestations have occurred over wide areas of Texas and in Louisiana, and recoveries have been reported from Arkansas. This pest may be controlled with parathion at 0.125 pound, malathion at 0.25 pound, and endrin at 0.33 pound per acre. Toxaphene, DDT, BHC, and calcium arsenate were ineffective at dosages recommended for the control of other cotton insects.

Species of the genus Colaspis are widespread and often found on cotton, frequently on the foliage near the base of squares and bolls, where they usually feed on the bracts surrounding them, causing a shot-hole type of injury.

A beetle (Conotelus mexicanus Murray) was found on cotton in the Bard area of Imperial County, California, in late August 1958.

The corn silk beetle (Luperodes brunneus (Crotch)) has been reported as a pest of cotton in localized areas in South Carolina, Georgia, Alabama, Mississippi, and Louisiana, but little is known about it.

The cotton square borer (Strymon melinus (Hbn.)) occurs throughout the Cotton Belt, but rarely causes economic damage. The injury it causes to squares is often attributed to the bollworm.

The cotton stainer (Dysdercus suturellus (H.-S.)) is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama,

Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing 10 percent of toxaphene or BHC 1 percent gamma will control insects of this genus. DDT may also be effective.

The cotton stem moth (Platyedra vilella (Zell.)), a close relative of the pink bollworm, was first discovered in the United States in 1951, when larvae were found feeding in hollyhock seed at Mineola, Long Island, N. Y. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcaucasia, Turkestan, and U.S.S.R., and as feeding on hollyhock and other malvaceous plants in England, France, and central and southern Europe. Collections made in 1953 extended its known distribution in this country to a large part of Long Island and limited areas in Connecticut and Massachusetts. Extensive scouting during 1954 disclosed that it had reached 11 counties in 4 States, as follows: Connecticut: Hartford and New Haven; Massachusetts: Essex and Plymouth; New Jersey: Monmouth, Ocean, and Union; New York: Westchester and all counties of Long Island (Nassau, Queens, and Suffolk). There was no reported spread in 1955, 1956, 1957, or 1958. Although this species has not been found in the Cotton Belt in the United States, it is desirable to keep on the lookout for it on cotton, hollyhock, and other malvaceous plants. In 1956 it was collected from a natural infestation on cotton growing on the laboratory grounds at Farmingdale, N. Y.

The cowpea aphid (Aphis medicaginis Koch), the green peach aphid (Myzus persicae (Sulz.)), and the potato aphid (Macrosiphum solanifolii (Ashm.)) are common on seedling cotton. Cotton is not believed to be a true host of these species.

The cowpea curculio (Chalcodermus aeneus Boh.) sometimes causes damage to seedling cotton.

The European corn borer (Pyrausta nubilalis (Hbn.)) was first reported on cotton in the United States during 1955. The first report came from Franklin County, Tenn., where a few plants near the edge of a field were severely damaged. This was on July 3 in a 3-acre field adjacent to one that was in corn the previous year. The cotton was only 8 to 10 inches high at that time, and the larvae had entered the stems 2 to 6 inches from the ground and burrowed up through their centers. In August light infestations were reported in cotton in Dunklin, New Madrid, Pemiscot, Butler, Stoddard, and Mississippi Counties in Missouri, and in Madison County, Tenn. The borers were found boring into the upper third of the stems, and second- and third-instar larvae were attacking small bolls. These records are of special interest in view of the fact that the European

corn borer is apparently spreading in the Cotton Belt. No reports of this insect on cotton were received during 1956 or 1957. In 1958 it was found boring in cotton stalks in Autauga and Madison Counties, Alabama, and in Washington County, Mississippi, in late July. In other parts of the world, particularly in Russia, Turkestan, and Hungary, it has been reported as a serious pest of cotton. One reference states "In Turkestan it is principally cotton which is attacked by the larvae and in which they bore long tunnels in the upper part of the stems." Entomologists and other interested persons throughout the Cotton Belt should be on the alert to detect its presence on cotton and, whenever possible, record the type and degree of injury, their seasonal and geographical distribution on cotton, and control measures that might be of value.

The pale-striped flea beetle (Systena blanda Melsh.), the elongate flea beetle (S. elongata (F.)), and S. frontalis (F.) sometimes cause serious damage to seedling cotton in some areas. They can be controlled with aldrin at 0.25 to 0.5 pound, dieldrin at 0.25 to 0.33 pound, DDT at 1 pound, or toxaphene at 2 to 3 pounds per acre in dusts or sprays. The sweetpotato flea beetle (Chaetocnema confinis Crotch) was found injuring seedling cotton in the Piedmont section of South Carolina in May 1954. Other species of flea beetles have been reported from cotton, but records regarding the injury they cause are lacking. When flea beetle injury to cotton is observed, specimens should be submitted to specialists for identification, with a statement regarding the damage they cause, the locality, and the date of collection.

Garden springtail (Bourletiella hortensis (Fitch)) injured cotton locally in Hertford County, North Carolina, in early May 1958.

The greenhouse leaf tier (Udea rubigalis (Guen.)), also known as the celery leaf tier, became extremely abundant on cotton in the San Joaquin Valley in 1954. Despite the heavy populations, damage was generally slight and restricted to foliage on the lower third of the plants in lush stands. In the few places where it was necessary to control this pest, a dust containing 5 percent of DDT plus 10 to 15 percent of toxaphene at 25 to 35 pounds or endrin at 0.4 pound per acre in a dust or spray was effective.

Several leafhoppers of the genus Empoasca are often abundant on cotton in many sections of the Cotton Belt. Only in California, however, has serious injury been reported, and this was caused by two species, solana DeL. (southern garden leafhopper) and fabae (Harris). These species are known to be phloem feeders on some crops and cause damage typical of this type of feeding on cotton. In the San Joaquin Valley, where fabae occurs, satisfactory control has been

obtained with 1 to 1.5 pounds of DDT per acre. In the desert areas, where solana occurs, parathion at 0.25 to 0.5 or malathion at 0.75 pound per acre has given satisfactory results.

Several of the leaf rollers (Tortricidae) occasionally damage cotton. Platynota stultana (Wlsm.) and rostrana (Wlk.) are the species most commonly recorded, but flavedana Clem., idaeusalis (Wlk.) and nigrocervina (Wlsm.) have also been reported. These species are widely distributed and have many host plants. P. stultana has at times been a serious pest of cotton in the Imperial Valley of California and parts of Arizona and New Mexico. DDT at 2 to 3 pounds or parathion at 1 pound per acre were the most promising materials tested.

The pink scavenger caterpillar (Pyroderces rileyi (Wlsm.)) is one of several insects that resemble the pink bollworm, and is sometimes mistaken for it by laymen. The larva is primarily a scavenger in cotton bolls and corn husks that have been injured by other causes.

The adults of the buprestid Psiloptera drummondi L. & S. occasionally cause damage to cotton. The damage consists of partially girdled terminals which break over and die. Control measures were directed against this insect on a 10-acre cotton field at Dona Ana, New Mexico, in August 1954, where 80 to 90 percent of the terminals had been clipped. A 5-percent DDT dust applied by air at 30 pounds per acre gave good control.

Root aphids known to attack cotton are the corn root aphid (Anuraphis maidi-radicis (Forbes)), Trifidaphis phaseoli (Pass.), and Rhopalosiphum subterraneum Mason. So far as is known, injury prior to 1956 was confined to the Eastern Seaboard. Trifidaphis phaseoli (detd. by L. M. Russell) destroyed spots of cotton up to $1\frac{1}{2}$ acres in fields in Pemiscot County, Mo., in 1956. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant (Lasius alienus americanus Emery). Chemical control of root aphids has been directed at this ant. Some of the new materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows injury without any evidence of insects being present, the underground portions should be examined carefully. Ant mounds at the base of these plants indicate the presence of root aphids.

The salt-marsh caterpillar (Estigmene acrea (Drury)) can be controlled with a dust or spray containing DDT-toxaphene (1:3) applied at 4 to 6 pounds of total toxicant, parathion at 0.5 to 1 pound, or a spray of endrin at 0.4 to 0.5 pound per acre.

The serpentine leaf miner (Liriomyza propepusilla Frost) has been present in large numbers in some areas during the last few years. Drought conditions favor infestations of this pest. Heavy infestations may result in considerable leaf shed. Field tests at Waco, Tex., showed that the best reductions were obtained with parathion at 0.25 pound per acre.

Snowy tree cricket (Oecanthus niveus (DeG.)) infestations caused alarm to some southwestern Oklahoma cotton growers in mid-July 1958. Approximately 3 percent lodging occurred in the Blair area.

The stalk borer (Papaipema nebris (Guen.)) is widely distributed east of the Rocky Mountains. It attacks many kinds of plants, including cotton, and is so destructive that one borer in a field may attract attention. The borers are most likely to be noted near the edges of cotton fields. Light marginal injury occurred in scattered fields in Missouri during June 1957, and it was also reported as causing some injury to cotton in Mississippi and Tennessee in 1956. It is sometimes mistaken for the European corn borer. Clean cultivation and keeping down weed growth help to hold them in check. The use of stalk shredders early in the fall should reduce their numbers. Information is needed concerning the effectiveness of chemicals for the control of this insect.

Whiteflies, Trialeurodes abutilonea (Hald.), T. vaporariorum Westw., and Bemisia tabaci (Genn.), are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Bemisia tabaci (Genn.) is reported to be a vector of the leaf crumple virus of cotton.

A white grub, Phyllophaga ephilida (Say), was reported to have destroyed 5 acres of cotton in Union County, N. C., during 1956. As many as 20 larvae per square foot were found. P. zavalana Reinhard is also reported to be a pest of cotton in the Matamoros area of Mexico, where the adults feed on foliage, particularly in the seedling stage. It is known to occur in Zavala and Dimmit Counties, Texas. P. cribosa Leconte, sometimes known as the "4 o'clock bug" in west Texas, has also been reported as feeding on young cotton in that area.

The white-lined sphinx (Celerio lineata (F.)) occasionally occurs in large numbers in uncultivated areas and migrates to cotton. It may be controlled on cotton with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre in a dust or spray. Migrations may be stopped with barrier strips of 10-percent DDT or 20-percent toxaphene or physical barriers.

Occasionally the yellow woollybear (Diacrisia virginica (F.)) and the hairy larvae of several other tiger moths (Arctiidae), including Callarctia phyllira (Drury), C. arge (Drury), and C. oithona Strk., cause serious damage to cotton. Information is needed in regard to their seasonal host plants, distribution, natural enemies, causes of serious outbreaks in cotton fields, life history, and control. Determinations by specialists should always be obtained.

CONFEREES AT TWELFTH ANNUAL CONFERENCE

One hundred and two entomologists and associated technical workers concerned with cotton-insect research and control participated in this conference. They were from the agricultural experiment stations, extension services, and other agencies in 16 cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by the following conferees:

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